



# Tone feature analysis: applications to Grassfields Bantu languages

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Cette version modifie la version publiée en corrigeant quelques erreurs matérielles et en améliorant le format de l'ère préinformatique qui était parfois difficilement lisible.

La pertinence de cet article est confirmée au début de 21<sup>e</sup> siècle par ses mises en gardes contre la confusion de "modélisation" et "théorie". La théorie mise en oeuvre ici ne diffère pas de façon essentielle de la théorie des traits distinctifs développée par l'école de Prague. La modélisation proposée est purement descriptive, fondée sur la supposition d'un état de langue comportant une opposition de deux registres tonals et ayant pour fonction la transformation de formes d'entrée exprimées dans ce système en différentes formes de sortie, généralement plus complexes. Il s'agit d'un exercice formel qui peut au mieux révéler des "points d'achoppement" qui ont déterminé des changements dans le système d'origine. Il ne prétend en aucune façon reproduire des faits ou des comportements langagiers. Il reste une simple représentation des données.

## ***TONE FEATURE ANALYSIS : APPLICATIONS TO GRASSFIELDS BANTU LANGUAGES***

### **0. INTRODUCTION**

0.1 One of the most useful tools for tonological description to have been developed in recent years is undoubtedly the notion of the "floating" tone. This notion has been applied to clarify the puzzling tone systems of several Grassfields Bantu languages, starting with Voorhoeve's (1971) article on Bamileke. These languages are shown to have two basic tonal entities (H and L tones) and a number of derived tonal entities which appear in phonetic realizations as a result of application of a set of rules to lexical patterns. The derived entities are often "downstepped" variants of the basic ones.

Hyman (1986) describes another language in this group (Ngamambo) by using floating (or "unlinked") tones in a variant of the "autosegmental" approach (Goldsmith 1976 and much subsequent literature). This approach is an attempt to integrate several widely held views on the nature of African tone systems into generative grammar, and draw parallels with other formally similar phenomena. In particular, it recognizes that tone patterns (sequences of tonal units) are in some sense independent of segmental (CV) sequences, and that the two sequences are "associated" or "linked" in explicitly definable ways. It is thus possible to assign a single tone pattern to a given morpheme, but allow it to be distributed differently over the tone-bearing units (TBUs) of that morpheme in different contexts. Likewise, a single grammatical tone pattern can be distributed by rule over segmental sequences of varying length. At some stage in a derivation, tones may not be associated with any TBU; these are floating tones. In the Grassfields Bantu languages, some tones float in lexical forms.

The way in which patterns and TBUs are associated can change in the course of a derivation. A distinction can be made, however, between the results of tone spreading, in which only the domains (i.e., the sequences of associated TBUs) of the tones in the pattern change, and tone assimilation (or copying), where the tonological identity of a tone in the pattern changes. Authors using the autosegmental approach prefer spreading rules (which involve redrawing association lines between tones and TBUs) to rules which operate only on the pattern and do not involve reassociation, for the purpose of describing both spreading and assimilation, particularly when the latter is associated with downstepping.

0.2 There are at least three major types of tone assimilation:

1) Type HLH → HMM: The number of tonological units (and hence, changes of level) remains the same.

2) Type HLH → HHH: There is complete assimilation but, as in type 1) , no indication of the direction of assimilation.

3) Type HLH → HH'H or H'HH: There is complete assimilation, reduction of the number of level changes, and proof of the progressive or regressive nature of the assimilation.

None of these types is easily dealt with by spreading rules alone. A phonological analogy will show the difficulty encountered by the most likely candidate for such treatment, type 3. Suppose a language where  $t \rightarrow c$  after  $i$ ,  $ei \rightarrow ee$ , and forms such as  $-eec-$  appear. This is a classic case justifying rule ordering: we may suppose a lexical form  $-eit-$  to which the palatalization and vowel assimilation rules apply in sequence. We would not, however, want to have a derivation containing such forms as  $-eeit-$  (which would be equivalent to inverting the order of the rules), or  $-eeic-$  (which would contain a redundant element).

Yet this is, in essence, what is achieved by allowing spreading rules to describe downstep (e.g.,  $H_1LH_2 \rightarrow H_1H_1LH_2 \rightarrow H_1H_1^+H_2$ ). The first H spreads to the segment formerly associated with L, without affecting the identity of this L. A second rule then allows the displaced L to disappear after leaving a trace of its earlier existence (downstep) on  $H_2$ .

The floating L tones created by this approach were soon recognized to result in a certain "cluttering" of the bottom line of derivations, e.g., in Clements and Ford (1979:208):

"...[F]loating tones remaining in the final line of derivation are not transmitted to the representation that constitutes the 'score' or input to the set of instructions making up the articulatory component..., or else are transmitted to that component but are simply ignored, by convention, in realization".

Later solutions assume the floating tones are not actually tones at all, but simply operators responsible for downstep, e.g., in Stewart (1983:57):

"...[N]ot only nonautomatic downsteps but also automatic downsteps are analyzable as floating low tones",

and Hyman (1986:135):

"The floating L [obtained by delinking in Ngamambo] ... is the downstep operator".

0.3 Unlike spreading rules, which generally treat tones as monolithic entities such as H, M, L (but see Hyman's 1986 innovations), assimilation rules can break tones down into sets of component features whose values can be changed in certain contexts to resemble those of neighboring tones. Discussions of tone features have, however, been largely confined to ways of obtaining matrices to define the full set of registers in any possible system (again, see Hyman 1986 for a review of recent proposals). Little has been said about non-distinctive features, though they can provide another way of describing downstep that accords better with the customary treatment of phonological processes such as the ones in the example above.

If, for example, some feature of a L tone is allowed to assimilate the same feature of a neighboring H tone, the L can then undergo assimilation of its own distinctive features by some third tone (or be deleted). The sequence of matrices will show the affected H tone to be different from what it would have been if the L had not previously been present in its original form, and can be interpreted accordingly (e.g., as requiring downstepping).

0.4 The purpose of this paper is to test whether such an approach can be successfully applied to a sampling of Grassfields Bantu languages in which floating tones are known to have a major role. The multiplicity and originality of the ways in which the tone systems of these languages have diverged should reveal the strong and weak points of the analysis more effectively than a study of abstract or more widely represented systems.

In all cases, it will be assumed that there has been a prior lexical association of tone patterns to TBUs in these languages, so that we can start with a string of tones, some of which are linked to TBUs and some of which float. We will provide each tone in the string with a matrix of features. Our rules will do no more than change the values of these features or delete tones entirely. At the end of a derivation, we will be left with a subset of the original string. All members of this subset will be tonetically realized; there will be no floating tones or independent downstep markers left over.

0.5 Since floating tones result from lexical association, it will be helpful to have a binary feature  $[\pm s]$ , so that tones which must be associated with matrices of TBU features can be marked  $[+s]$ , and tones which float,  $[-s]$ . (This situation should be distinguished from the one in which a tonal morpheme is spread over more than one segmental morpheme, as when verb forms require a given tone on a pronominal subject ; the tone in question cannot properly be said to float.

It might be argued that the feature  $[\pm s]$  is superfluous and merely signifies that the tone is or is not associated with a TBU matrix. It is true that, if  $[+s]$  becomes  $[-s]$ , the tone has simply been "delinked" from its TBU. But when  $[-s]$  becomes  $[+s]$ , there is nothing in the change itself to indicate what TBU matrix is now to be associated with the tone. This must be decided by a separate rule, e.g., one which requires the formation of a glide or the copying of a neighboring segment. This feature is thus more of an instruction to find or maintain a suitable relationship between tone and TBU, than a simple statement of (dis)association.

Whether a form of shorthand or not, this feature will prove useful in formulating some of the "shunting" rules below.

0.6 We now turn to "marking" features. These are always tonologically *redundant* in one of two ways: in the lexicon,

1) either they have the same value for all tones (whatever the value of the distinctive tone feature(s)), or

2) they differ in value, exactly as the distinctive feature does.

There is a third option of assigning them a "neutral" value in the lexicon and letting them receive interpretable values in the course of the derivation. This choice (underspecification) is an extremely useful formal device ; it will not be discussed here, however, as it is not required for these languages.

Marking features allow each toneme to have as many tonetic realizations as the number of values these features can have. Thus, if the value of a marking feature cannot be changed for a given toneme, only one realization is allowed. A tone which can take either the lexical or another value of the marking feature will, however, have two possible tonetic realizations, and so forth. If there is more than one marking feature, the number of possibilities is obtained by multiplication.

Using these features, we can mark tonemes in specific tonological and sometimes syntactic contexts to reflect the presence of some other toneme in the environment. This is done simply by changing the lexical value of the marking feature.

The desired result can be obtained either directly or indirectly:

1) when the realization of a given tone in a given context must be different from what it would be if the tone retained its lexical value for the marking feature, this value can be changed directly by rule;

2) it should not be possible to cancel such changes. If the fate of the marked tone in the remainder of the derivation is liable to result in cancellation, the changed value may be *transmitted by copying* to a neighboring tone.

0.7 After the application of a set of feature-changing rules, each tone in a string can be defined by its tonological identity (determined by its distinctive feature values) and relatively to other members of its own class (according to its marking feature values). A distinction between tonemics and tonetics is thus maintained. In the languages analysed below, only one such distinctive feature is required,  $[\pm h]$ . Every tone is either H or L *by nature*; all distinctions within these two classes are tonetic and determined by the marking features.

0.8 Another "component" of the grammar will interpret matrices constructed of all these types of features and assign a real tonetic value (frequency) to each tone. This tonetic interpretation will have to be a function of both the segmental context and the prior development of the utterance from its outset.

0.9 To establish its *domain of application*, any tone rule may have to refer to a specific set of syntactic contexts as the only ones in which it applies. As the published data on which the analyses below are based are essentially limited to citation forms of nouns and noun phrases (including the associative construction 'N<sub>1</sub> of N<sub>2</sub> (...of N<sub>n</sub>)'), most of the rules are provisionally contextualized for these syntactic structures.

Many rules apply to both individual lexemes and larger constructions containing them. As usual, they will apply across phrases from left to right, whenever they can, and over the longest possible strings.

Some other rules may, however, have to apply first to lexemes (e.g., to individual nouns) and then, perhaps in slightly different form, to phrases (e.g., the associative construction) after some intervening rules.

0.10 From the standpoint of their *function*, the feature-changing rules used in the descriptions below are (deletion rules aside) basically of three types:

- 1) rules which introduce changes in the value of the marking features;
- 2) rules which assimilate the marking-feature values of neighboring tones ; and
- 3) rules which assimilate the distinctive-feature values of neighboring tones.

It will be found, however, that applying *only* rules with these functions can lead to a few erroneous results. These can be avoided by changing the values of structural features of the [ $\pm$ s] type in certain contexts. These changes will shift the cases involved into a different category for subsequent rules, so that the derivation will proceed as desired. Rules having this function may be called "shunting" rules, since they put derivations, so to speak, on different tracks.

0.11 Analyses of the tone systems of four Grassfields Bantu languages will now be developed according to the above principles. These languages are : Dschang Bamileke, Ghomala' Bamileke, Ngamambo, and Mankon. They have been selected on account of the completeness and quality of the published descriptions: Hyman and Tadadjeu (H&T 1976) on Dschang, Nissim (1981) on Ghomala', Asongwed and Hyman (A&H 1976) and Hyman (1986) on Ngamambo, and Leroy (1977) on Mankon. The rule systems below attempt simply to translate these authors' original analyses into the framework described in the preceding paragraphs. Even this limited sampling turns out to provide us with a wide range of divergencies and resemblances.

The analyses concentrate on the rules required to derive the forms observed in the noun associative construction, where the most interesting phenomena appear, but there are also a few remarks on Dschang verb tonology. Space will not allow derivations to be presented for every possible pattern in the associative construction for each language, but representative examples are given in (19), (30), (45), and (55) below, to show how the rules are intended to work.

## 1. DSCHANG BAMILEKE

1.1 There is no observable downdrift in Dschang Bamileke. In order to explain downstepping, however, let us assume that, at some point in certain derivations, HL glides are formed, and that the L tones in these glides are affected by a larger than usual drop in pitch. Let us then add a redundant binary feature, say [ $\pm$ q], to all tone matrices so that the two tones appearing in lexical patterns will be characterized as:

- (1) H / L  
 [+h] / [-h]  
 [-q] / [-q]

The value of the feature [q] can then be altered in glides by a rule like

$$(2) \quad -q \rightarrow +q / [+h] \begin{array}{c} [-h] \\ \boxed{\phantom{q}} \end{array}$$

⏟

The positive value of the feature [q] will ultimately be interpreted as a lowering of the pitch of the tone so marked, with respect to the level it would otherwise have reached as a continuation of the preceding sequence of tones (if any). Likewise, the negative value means there is no pitch drop, and this level is reached.

1.2 Dschang roots have been diachronically reduced from two syllables to one. Rather than forming glides, the tones of the lost vowels have been left "floating" in most cases. It is therefore convenient to assign a syllabicity feature, [ $\pm s$ ], to the tones in lexical patterns.

When .LL roots appear in final position, the second tone is deleted and the first is downglided. This is the "demarcative" intonation which can be found in many Central African languages. In the same position, the L of LH roots is not downglided. There are several ways of writing rules to describe this phenomenon. We will simply suppose that L tones have an additional feature, [ $\pm r$ ], and that there is a rule:

$$(3) \quad -r \rightarrow +r / \begin{array}{c} [-h] [-h] \# \\ [+s] [-s] \\ \boxed{\phantom{r}} \end{array}$$

1.3 Dschang has nouns which appear in citation with the tone pattern L.'H. These are assumed to derive by rule from a lexical L.HL pattern, which completes a paradigm having L.LL, L.LH, and L.HH as its remaining members. For the effects of the following discussion, let us assume that .HL roots are already marked as glides in the lexicon. The four basic root patterns will thus have the following lexical matrices:

$$(4) \quad \begin{array}{cccc} \text{.L L} & \text{.L H} & \text{.H H} & \text{.H L} \\ [-h][-h] & [-h][+h] & [+h][+h] & [+h][-h] \\ [-q][-q] & [-q][-q] & [-q][-q] & [-q][-q] \\ [+s][-s] & [+s][-s] & [+s][-s] & [+s][-s] \\ [-r][-r] & [-r] & & \begin{array}{c} [-r] \\ \text{⏟} \end{array} \end{array}$$

1.4 Examination of the tonal behavior of nouns in the associative construction shows that some kind of grounding rule must apply to the tone of the associative marker. A possible formulation of this rule is:

(5) If the tone of the associative marker can be grounded so as to form a HL glide, either with the final root tone of  $N_1$ , or with the tone of the prefix of  $N_2$  (but not with the first root tone of  $N_2$  in the case of  $\emptyset$ -prefix), it must be.

The following is a formal abbreviation of (5):

(6) [+h][-h] → [+h][-h]

· · ·  
· · ·  
· · ·  
          ⌒

C<sub>1</sub>: A P<sub>2</sub>

C<sub>2</sub>: S<sub>1</sub> A

C<sub>1</sub> and C<sub>2</sub> are contexts in which the rule applies (A = associative marker, S<sub>1</sub> = root tone of N<sub>1</sub>, P<sub>2</sub> = prefix tone of N<sub>2</sub>, S<sub>2</sub> = root tone of N<sub>2</sub>)).

Final *ungrounded asyllabic root tones* now become superfluous and may be deleted (Deletion 1). *Ungrounded associative marker tones* must, however, be conserved until a final deletion rule.

1.5 The associative marker can thus be grounded in the following ways:

I. The associative marker has a H tone and is linked to the L-tone prefix of N<sub>2</sub>. After deletion of asyllabic tones, this form of grounding yields the following set of observed sequences:

- 7) a. .L      L.'L      (< N<sub>2</sub> = L.LL or L.LH)  
b. .H      H.'H      (< N<sub>2</sub> = L.HH or L.HL)  
c. .L      'H.H      (< N<sub>2</sub> = L.HH or L.HL)  
d. .H      H.L      (< N<sub>2</sub> = L.LL or L.LH)

C : .S<sub>1</sub>      P<sub>2</sub>.S<sub>2</sub>

(The H of S<sub>1</sub> in 7b and 7d may or may not itself be downstepped.)

II. The associative marker is L and is grounded to an asyllabic N<sub>1</sub> root-final H. The preceding root tone in N<sub>1</sub> may be H or L. The first tone of N<sub>2</sub> may be L, or H in case N<sub>2</sub> has Ø prefix. After deletion of asyllabic tones, the observed sequences are:

- (8) a. .L      'L  
b. .H      L  
      .S<sub>1</sub>      P<sub>2</sub>. / S<sub>2</sub>  
c. .L/H      'H  
      .S<sub>1</sub>      S<sub>2</sub>

Since the associative marker is marked as asyllabic, the glides produced by I. will (like the root-internal glides) be *partially asyllabic*, while those produced by II. will be *entirely asyllabic*.

1.6 H&T (1976) cite variants in which the associative marker is syllabic:

I'. The H tone of the associative marker is grounded to the L N<sub>2</sub> prefix. This is observed when the *first* N<sub>1</sub> root tone is L, and the first N<sub>2</sub> root tone is H, the result being:

- 9.) .L    'H    H.H      or    .L    'H    H  
      .S<sub>1</sub>    A    P<sub>2</sub>.S<sub>2</sub>      .S<sub>1</sub>    A    S<sub>2</sub>

II'. The L tone of the associative marker is grounded to the final H N<sub>1</sub> root tone. This is found with preceding L N<sub>1</sub> root tone and following L N<sub>2</sub> prefix, the observed result being:

$$(10) \begin{array}{ccc} .L & 'L & L. \\ .S_1 & A & P_2. \end{array}$$

II". In an exceptional case, the associative marker becomes obligatorily segmental when,  $N_1$  and A being as in II',  $N_2$  is  $\emptyset$ .HH. The observed result is:

$$(11) \begin{array}{lll} .L & 'H & H \\ & .S_1 & A \quad S_2 \end{array}$$

1.7 The data show that, if the glide formed by grounding is preceded by H and followed by L, the ordinary HL interval will appear in the observed sequence, i.e., there is no pitch drop or downstep. Rule (2) representing pitch drop must therefore be reformulated with a more restricted context of application. This is precisely:

(12)  $-q \rightarrow +q /$

	$\langle$	$\begin{matrix} [-h] \\ [-q] \end{matrix}$	$\rangle$	$\begin{matrix} [+h] & [-h] \\ & \square \end{matrix}$	$\langle [+h] \rangle$
		$(\frown)$		$\smile$	
$C_{HL} :$		$P_i.$		$S_i$	$S_i$
$C_1 :$		$S_1$		$A$	$P_2. \quad S_2$
$C_2 :$		$S_1$		$S_1$	$A \quad P_2. / S_2$

The angled brackets indicate that at least *one* of the bracketed elements must be present for the rule to apply. The first tone in the structural description may be part of a glide, but must be [–q] ; the last must not be part of a glide. The rule must apply to the components of the associative (or any other) construction recursively from left to right. This will sometimes prevent the specified feature change from taking place in two successive glides with no intervening tone. The context C<sub>HL</sub> covers only nouns with a L.HL lexical pattern. C<sub>1</sub> and C<sub>2</sub> correspond to the possible associative-marker grounding contexts.

1.8 In the Dschang data, no glides are realized (except the final L offglide). The glides created by (12) must therefore be eliminated by the application of a set of rules. These are designed to reduce all glides to a sequence of two tones which have identical values for [h] and [q]. Whenever (12) has given [q] a positive value, this marking will be conserved, either on the result of the glide reduction or on the immediately following tone.

Before stating the rules required to do this, we must provide for the exceptional cases of variants I', II' and II".

Dschang prefers to avoid downstep before a prefix. This can happen in context C<sub>2</sub>. An epenthetic segment is therefore created for the glide, and its tone will ultimately be determined by:

$$(13) \text{ -s} \rightarrow \text{+s} / \begin{matrix} [-h] & [+h] & [-h] & [-h] \\ & [-] & & \end{matrix}$$

The final [-h] tone *cannot* correspond to S<sub>2</sub>.

II' has now been provided for. There is, however, another structural description for the creation of an epenthetic segment, and a rule to determine its tone which is disjunctive with (13) in C<sub>2</sub>, and also applies in C<sub>1</sub> (and, like 13, in verb tonology). It requires that the first part of a glide be [+s] when preceded by a L *which is not itself part of a glide*, and followed by a H. This requirement holds, whatever the value for [s] of the second part of the glide.



$$(14)_{-S} \rightarrow +S / \begin{array}{cccc} [-h] & [+h] & [-h] & [+h] \\ & & \underbrace{\quad} & \\ & & [-] & \end{array}$$

This rule will account for cases I' and II". In all cases, the [s] feature change is copied from a preceding TBU.

1.9 We now require a disjunctive copying rule depending on the value of the feature [s] for the first tone in a HL glide:

(15)  $-q \rightarrow +q /$

i.

$\begin{array}{ccc} [-q] & [+q] & [-] \\ [-s] & & [+s] \end{array}$

ii.

$\begin{array}{cc} [-] & [+q] \\ [+s] & \end{array}$

If (15i) has applied, we can now apply:

(16)  $+q \rightarrow -q / \begin{matrix} [-q] & [-] \\ [-s] \end{matrix}$

After (15) and (16), the value for the feature [q] is now identical for both tones in all glides. In a suitable framework for stating shifting rules (see 5.3), (15i) and (16) could be combined in a single rule.

1.10 Now that glides are identical for [q], we may introduce a leveling rule to make them identical for [h]:

(17) a.  $-h \rightarrow +h / \underbrace{[+h] [+h] [-]}_{\text{([}\pm h\text{])}}$  i.  
           /  $[-h] [+h] [-]$  ([+h]) ii.  
       b.  $+h \rightarrow -h / \underbrace{[-h] [-] [-h] [-h]}_{\text{([}h\text{])}}$

$$\begin{array}{llll} C_{HL}: & P_i. & S_i & S_i \\ C_1: & S_1 & A & P_2. \quad S_2 \\ C_2: & S_1 & S_1 & A \quad P_2./S_2 \end{array}$$

This rule, like (12), must apply recursively from left to right across the components of the construction.

1.11 Any remaining tone, whether part of a glide or not, with the feature [-s] in its matrix may now be deleted (Deletion 2). Glides which differ in value for the feature [s] are thus reduced to single tones and eliminated. It must be remembered, however, that (14) has created some *entirely syllabic* glides. For these, the following alternative must be provided:

(18) a. either the first (epenthetic) part of the glide is deleted (by analogy with the regular case where there is no marker between the terms); or

b. the glide is dissolved and the second part becomes  $[-q]$ .

(19) Examples of derivations in Dschang:

̀̀ndzà				̀̀mbhé			'axe of dog'
L	L	H	L	L	H	L	
							5
			+q			+q	12
		+s					13
		+q			+q		15ii
		-h					17b
						+h	17aii
			∅			∅	deletion 2
L	L	'L		L	'H		

àpú`´				m̀bhú`´			arm of dog'
L	H	L	H	L	H	L	
							5
		+q				+q	12
(12 and 14 cannot apply to ´m̀.)							
	+q				+q		15ii
				+h		+h	17ai
		Ø	Ø			Ø	deletion 2
L	'H			H	'H		

ḡká ´ `				ṇdzwì `			'monkey of leopard'
L	H	H	L	L	L	L	
					+r		3
		⌒					5
						Ø	deletion 1
(12 and 13 cannot apply.)							
			+h				17ai
		Ø	Ø				deletion 2
L	H			L	'L		

l̥ə́sɔŋ ˈˈ				n̥tsɔŋˈ			'feather of thief'
L	H	H	H	L	H	H	
							5
			⌒				5
		∅				∅	deletion 1
				+q			12
					+q		15i
				-q			16
				+h			17ai
			∅				deletion 2
L	H			H	'H		

àpà ˊˊ				m̀bhú ˊ			'bag of dog'
L	L	L	H	L	H	L	
							5
		Ø					deletion 1
				+q			12
(12 cannot affect m̀bhú ˊ.)							
			+s				14
			+q				15ii
				+h			17aii
						+h	17ai
						Ø	deletion 2
				-q			18b
L	L		'H	H	H		

̀ndzà ˊˊ				śog ˊ		'axe of bird'
L	L	H	L	H	H	5
						5
					Ø	deletion 1
			+q			12
		+s				14
		+q				15ii
			+h			17aii
			Ø			deletion 2
L	L	'H		H		

1.12 It is possible to describe Dschang verb tonology by constructing a set of rules allowing LH glides to form on L-tone verbs. Let us assume, however, that verb tonology should be made to resemble the noun system as far as possible. Aside from proper contextualization of the rules, this will require an additional restriction:

(20) If a verb root becomes [+q] in the course of a derivation, it remains so; and [+q] is not copied onto any neighboring tone.

Glides which are not identically marked for the feature [q] are therefore possible in this part of the tonology. Thus,

(21)	´	<b>kðŋ</b>	´	'and liked'
	H [+s] [+nasal]	L	H	
	⌣			~5
		+q		~12
		+h		~17a (modified)
			Ø	deletion
	H	'H		

Right shunting of two successive L tones could plausibly be invoked in the following derivation:

(22)	à	´	˘	<b>kðŋ</b>	´	'he is about to like'
>	à L	´ H	<b>kðŋ</b> L [+s]	˘ L [-s]	´ H	shunting
		⌣				~5
			+q			~12
		+s				~13
		-h				~17b
				Ø	Ø	deletion
	L	L	'L			

Otherwise, derivations proceed normally although, as already in (21), some floating tones turn out either to be lexically [+s] or to have undergone some prior derivation, perhaps involving early deletion and grounding rules.

(23a)	à	kè	´	kòŋ	´	`	´	'he liked (yesterday)'
	L	H	H	L	H	L	H	
						[+s]		
			⌣		⌣			5
				+q		+q		12
				+h				17aii
						+h		17ai
			Ø		Ø		Ø	deletion
	L	L		'H		'H		

(The structural description of (14) is met by **kè ´ kòŋ ´** but the rule does not apply in this context. Note that (15) does not allow the syllabic floating tone to transmit the [+q] marking to the following asyllabic H.)

(23b)	à	kè	´	kòŋ	´	`	´	`	mó	`	'he liked a child (yesterday)'
	L	L	H	L	H	L	H	L	H	L	
						[+s]	[+s]			⌣	
			⌣		⌣						~5
				+q		+q				+q	~12
							+q				~15i
									+q		~15ii
						-q					~16
				+h							~17aii
						+h				+h	~17ai
			Ø		Ø			Ø		Ø	deletion
	L	L		'H		H	('H)		'H		

(The H-tone object marker becomes syllabic when an object is present. No glide is allowed to form between this marker and the following asyllabic prefix.)

## 2. GHOMALA' BAMILEKE

2.1 Ghomala' can be described by simplifying both the lexical patterns and the system of tone rules in Dschang. The final floating tone in roots can be omitted except in the case of LH. All root tones can be marked [+s], and all prefix tones [-s] *except* in the case of L.H < \*L.HL. The values of the syllabicity feature are then adjusted at the beginning of the derivation, before a pitch drop is inserted. Let us thus assume the following lexical patterns:

(24)

L	.L		L	.L	H		L	.H		L	.H
[-h]	[-h]		[-h]	[+h]	[+h]		[-h]	[+h]		[-h]	[+h]
[-q]	[-q]		[-q]	[-q]	[-q]		[-q]	[-q]		[-q]	[-q]
[-s]	[+s]		[-s]	[+s]	[+s]		[-s]	[+s]		[+s]	[+s]
[-r]	[-r]		[-r]	[-r]			[-r]			[-r]	

Notice that the partially syllabic L.H nouns (H citation form from \*L.HH) and the entirely syllabic ones (LH citation form, from \*L.HL) are distinguished only by the use of the feature  $[\pm s]$ .

The equivalent of rule (3) is now:

$$(25) -r \rightarrow +r / \begin{matrix} [-h] \# \\ [+s] \\ [ \_ ] \end{matrix}$$

2.2 Two neutralizations are observed:

1. all patterns containing a H tone neutralize before a following L;
2. partially and entirely syllabic L.H patterns do not contrast after a preceding H.

Both can be obtained by:

$$(26) +s \rightarrow -s / <[+h]> \begin{matrix} [-h] [+h] <[-h]> \\ [ \_ ] [+s] \end{matrix}$$

applying to LH and entirely syllabic L.H nouns. (Angled brackets again signify the inclusive disjunction of the features in question.)

Additional contrasts are possible before pause and H; thus:

$$(27) +s \rightarrow -s / \begin{matrix} [-h] [-h] [+h] \{ [+h] \\ [+s] [ \_ ] \} \{ / \\ \# \} \end{matrix}$$

where the rounded brackets indicate exclusive disjunction of the contents, applies to L.LH nouns.

2.3 Once the necessary adjustments in the lexical matrices of the L.LH and entirely syllabic L.H patterns have been brought about, rule (5) from Dschang can form glides in the associative construction. The same type of rule can also apply to postposed possessives and preposed modifiers in appropriately defined contexts.

Once glides have been formed, all noun tones which are marked  $[-s]$  and are not part of a glide can be deleted (Deletion 1).

There is now a rule making glides formed by the L-tone associative marker entirely syllabic:

$$(28) -s \rightarrow +s / [+s] [ \_ ]$$

This means that glides formed with root tones become entirely syllabic, while glides formed with prefix tones remain entirely asyllabic.

2.4 The value of the marking feature [−q] is now changed for the L tone of asyllabic glides, provided the tones to the immediate left and right of the glide are the same.

(29)  $-q \rightarrow +q / \begin{matrix} [\alpha h] & [+h] & [-h] & [\alpha h] \\ & [-s] & [-s] & \\ & & \boxed{\phantom{0}} & \\ & & \text{---} & \end{matrix}$

thus corresponds to (12) in Dschang.

(15i) now applies. Since there is no backward copying, the equivalent of (15ii) is unnecessary. There is also no need for the feature values of both parts of glides to be made identical, as they are simply to be deleted. Rules (16) and (17) can therefore also be eliminated, and the derivation moves directly to the deletion of all [–s] tones (Deletion 2). Syllabic tones with no corresponding vowel matrix are associated with the closest TBU to the left.

(30) Examples of derivations in Ghomala'

´	mú	´	gəpə	'child of chicken'
L	H	L	LH	
	⌒			5
Ø				deletion 1
		+s		28
	mû		gəpə	

dyó		bàp			'house of animal'	
L [+s]	H	L	L	L	H [+s]	
-s						26
					-s	27
	⌒					5
Ø			Ø		Ø	deletion 1
		+s				28
	dyÊ			bap		

´	táj	´	gòpá		'ear of chicken'
L [+s]	H	H	L	H	
			–s		26
		◡			5
			+q		29
				+q	15i
		Ø	Ø		deletion 2
tǎj		'góp			

˘	kò?	˘	˘	˘	guə	'rooster of guest'
L	L	H	[+s]			
			+r			25
	-s					26
		⌒				5
Ø	Ø			Ø		deletion 1
			+s			28
		kô?		guə		

m̀kòǎ			mú			'roosters of child'
L	L	H	H	L	H	
		[+s]				
		-s				27
						5
Ø		Ø				deletion 1
			Ø	Ø		deletion 2
mkoǎ			mú			

kwà			bàp			'foot of animal'
L	L	H	L	L	H	
					[+s]	
					-s	27
						5
Ø					Ø	deletion 1
				+q		29
				+q		15i
		Ø	Ø			deletion 2
kwà			'bap			

### 3. NGAMAMBO

3.1 Ngamambo has "underlying" H and L tones. We will therefore need a feature  $[\pm h]$ .  $[+h]$  and  $[-h]$  tones are, however, realized at different levels. Let us therefore also provide a marking feature which can take any one of five values, represented by the positive integers from 0 to 4. At the end of derivations,  $[+h]$  tones can be marked [1], [2], or [3] and  $[-h]$  tones can be marked [0], [3], or [4]. In the lexicon, however, we will start with all  $[+h]$  tones as [1], and all  $[-h]$  tones as [0].

Many Ngamambo nouns have lost their final vowels but kept a floating tone. The latter must be marked  $[-s]$ , while all tones on TBUs will be  $[+s]$ . We will make one exception to this general arrangement in the lexicon, for reasons which will become clear below: the final (theoretically floating) tone in all L.HH nouns with syllabic prefixes, and in H.LL nouns of class 6a (with L tone associative marker) will be marked  $[+s]$ .

Finally, we will mark all the tones of first root vowels  $[+q]$  and all other tones  $[-q]$ . This will give us a demarcative feature similar in type to  $[\pm s]$ .

We will thus have lexical matrices such as

(31)	L	.H	H		L	.L	H		H	.L	L		H	.H	L		L	.H	L
									class 6a										
	$[-h]$	$[+h]$	$[+h]$		$[-h]$	$[-h]$	$[+h]$		$[+h]$	$[-h]$	$[-h]$		$[+h]$	$[+h]$	$[-h]$		$[-h]$	$[+h]$	$[-h]$
	[0]	[1]	[1]		[0]	[0]	[1]		[1]	[0]	[0]		[1]	[1]	[0]		[0]	[1]	[0]
	$[+s]$	$[+s]$	$[+s]$		$[+s]$	$[+s]$	$[-s]$		$[+s]$	$[+s]$	$[+s]$		$[+s]$	$[+s]$	$[-s]$		$[+s]$	$[+s]$	$[-s]$
	$[-q]$	$[+q]$	$[-q]$		$[-q]$	$[+q]$	$[-q]$		$[-q]$	$[+q]$	$[-q]$		$[-q]$	$[+q]$	$[-q]$		$[-q]$	$[+q]$	$[-q]$

and so forth.

3.2 The derivations in the A&H 1976 dialect can begin with a set of marking rules:

$$(32) M1 : 0 \rightarrow 4 / \left[ \begin{array}{c} [+h] \# \\ \{ [-s] \} \\ | / | \\ \{ (X) [+s] \} \end{array} \right] \quad (X \text{ is any sequence of tones.})$$



- (33) M2a : 4 → 3 /    [+h] [ ] [+h]  
           C<sub>LH</sub> :    P<sub>i</sub>.    S<sub>i</sub>    S<sub>i</sub>  
       b : 1 → 3 /    [-h] [ ] [-h]  
           C<sub>HL</sub> :    P<sub>i</sub>.    S<sub>i</sub>    S<sub>i</sub>  
           C<sub>1</sub> :    S<sub>i</sub>    A    P<sub>2</sub>. (P<sub>2</sub> is syllabic.)  
           C<sub>2</sub> :    S<sub>i</sub>    S<sub>i</sub>    A  
       c : 1 → 2 /    [-h] [ ]                    i.  
           C<sub>1</sub> :    S<sub>i</sub>    A                    (P<sub>2</sub> is asyllabic.)  
           1 → 2 /    [-h] [ ]                    ii.  
                               |                    /                    \  
           C<sub>HH+</sub> :    P<sub>i</sub>.    S<sub>i</sub>    S<sub>i</sub> (A)

As a result of M1, where the rounded brackets again represent exclusive disjunction, a L still marked [0] at the end of a derivation will be downglided by the tonetic interpretation.

Notice that the structural description of M2a and b is [ $\alpha$ h] [- $\alpha$ h] [ $\alpha$ h].

M2cii changes a feature at the level of the tone pattern, i.e., in a tone appearing on two or more successive TBUs. This type of rule is a consequence of the decision to make the lexical value of the marking feature depend on the value of the distinctive feature. The tone on the individual TBU is thereby situated relatively to an absolute scale. When the lexical value of the marking feature is the *same* for all tones, each tone is situated with respect to a *standard interval* between itself and the preceding one.

The M2 rules are disjunctive among themselves, and can be applied from left to right over a phrase. Notice, however, that we could also have:

- (34) M2b' : 1 → 2 /    [-h] [ ]  
                               |                    /                    \  
                               V                    (V)                    (V))

disjunctive with M2a, but ordered *before*

- (35) M2c' : 2 → 3 /    [ ] [-h]  
           C<sub>HL</sub> :    S<sub>i</sub>    S<sub>i</sub>  
           C<sub>1</sub> :    A    P<sub>2</sub>                    (only if P<sub>2</sub> is syllabic.)  
           C<sub>2</sub> :    S<sub>i</sub>    A

Comparison of M2b and M2ci shows that the asyllabic prefix tone of monosyllabic nouns is not a suitable righthand environment for M2b.

The H tone of the anaphoric demonstrative (**te**) can be lowered by M2b after a final L N<sub>1</sub> root tone. However, to obtain

Λsiŋ ʌ rəbɛi te 'place of knives in question'  
   2 1 1 1 3 1

(where lowering does not take place), the possibility of optionally excluding the context N<sub>2</sub> + demonstrative from this rule must be allowed (perhaps because of ambiguity with 'place (in question) of knives?'), at least in the H 1986 dialect.

Only a preceding [-h] is required to bring about the change in M2c. This L may, however, already be marked 3 if M2a has applied to its left. M2c seems to be optional in some cases (see example 34a in H 1986), which may be related to the L having a 3 value.

3.3 We now turn to copying rules. The first of these involves copying *within* lexemes.

When the value for the feature [h] of a *syllabic* prefix tone is the opposite of the one for the root tones, the prefix tone may assimilate the first root tone. In many cases, the result is a glide consisting of the

assimilated root tone and the final one. This result is accounted for by the expedient of marking the second root tone of L.HH and some H.LL nouns [+s] in the lexicon. We can allow any [+s] tone without a corresponding matrix of vowel features to be interpreted as forming a glide with the immediately preceding tone. There are, however, other cases in which no glide is formed on L.HH nouns. These are covered by making the final tone asyllabic :

$$(36) S1 : +s \rightarrow -s / <[+h]> \begin{matrix} [-h] & [+h] & [+h] & <[+h]> \\ & & \boxed{\phantom{0}} & \\ & & \emptyset & \end{matrix}$$

$$C_{+HH+} : \quad A \quad P_{1,2} \quad S_{1,2} \quad S_{1,2} \quad A$$

Ø here means that this tone has no corresponding vowel matrix. The angled brackets are used as previously to signify that *at least one* of these features must be present for the rule to apply.

The first copying rule now applies, but only when the prefix/root complex is preceded by L or in initial position:

$$(37) C1 : \alpha h \rightarrow -\alpha h / \left\{ \begin{matrix} [-h] \\ \{ / \} [+s] \\ \{ \# \} \end{matrix} \right\}$$

$$C : \quad P_i \quad S_i \quad S_i$$

Assimilation of the distinctive feature, as in C1, requires simultaneous assimilation of the marking feature value (but the converse is false). This characteristic of the rule system, like the form of M2cii, is a consequence of having the marking feature depend on  $[\pm h]$ .

Copying of prefix tones must take place after the marking rules. Otherwise nouns like **m̀bàp'** 'rat' and **̀ngwí'** 'cloth' would behave in the same way in the associative construction. But they do not (H 1976:48).

Then another rule:

$$(38) S2 : -s \rightarrow +s / \begin{matrix} [\alpha h][\alpha h][-\alpha h][ -h] \\ \boxed{\phantom{0}} \end{matrix}$$

$$C_{HL/LH+} : \quad P_1 \quad S_1 \quad \bar{S}_1 \quad A$$

makes L.LH and H.HL roots *in N<sub>1</sub> position* analogous to L.HH and H.LL, respectively.

3.4 In the associative construction, the tone of the associative marker assimilates a prefix tone of opposite value. There is only one possible case, with H associative marker and L prefix:

$$(39) C2 : -h \rightarrow +h / \begin{matrix} [+h][ \phantom{0}] \\ C : \quad A \quad P_2 \end{matrix}$$

After copying, the associative marker and N<sub>2</sub> prefix may merge according to a phonological rule which need not concern us here. The two identical tones are reduced to one. If both are asyllabic, the tone resulting from the merger must be marked [+s]. It can then be interpreted as forming a glide with the preceding syllabic tone.

We are now at the stage where we can delete any tones left floating:

$$(40) D : \text{Delete any tone whose matrix contains the feature } [-s].$$

If, in fact, associative constructions of the type

Λzəɛ Λboɛ 'trap of slave' (< Λzə̀ɛ` Λ̀bbòɛ`)

2 1 3 0

appear in this form in both dialects, spreading would have to be included as a part of C1 as well.

If, however, nouns of the type **m̀bàp'** 'rat' now become 4-2 in N<sub>1</sub> position in the associative construction, this will be an anomaly in the new system. To become regular, the behavior of these nouns would have to merge with those of the **ngwí'** 'cloth' type. As mentioned above, this would mean that C1 could now precede the marking rules.

3.6 It is clear that the A&H 1976 dialect has a leveling rule in the associative construction:

(43) A2 : 3 → 2 / (T) T T (T is any TBU.)

(although there is one exception to this rule:

Λbam Λtsam 'bag of home',

4 4 3 2

which may be idiosyncratic). But the H 1986 dialect has other leveling rules:

(44) A3 : 2 → 3 / T T #  
  
 C : S Pos (see example 29)

A4 : 1 → 3 / T T (T) T i.  
  
 (x is any value other than 1.)

1 → 2 / T T (T) T ii.  
  
 C : S A P S,Pos

The feature [±q] may provide an alternative way of characterizing the contexts of these rules. The exact difference between the leveling rules in the two dialects, and between their scopes of application, cannot however be clearly expressed, as the data are not always comparable.

3.7 We now reach the level of tonetic interpretation. It is here that a sequence

[ 3] [ 3]

[-q] [+q]

can optionally be offset by a pitch drop, once and only once within a phrase. This will be a morphologically induced downstep. If the reason for its appearance were tonological (e.g., marking resulting from deleted tones) rather than morphological, it would appear necessarily at a specific point, even if a subsequent leveling rule were to prevent it from occurring elsewhere. But this is not the case. This downstep simply marks the beginning of a selected root where leveling rules would otherwise efface the boundary.

Another phenomenon that can be treated at this level is the disappearance of prefix tones from nouns with initial NC- in the H 1986 dialect. The best solution is not necessarily to treat these tones as floating, for there is a contradiction between:

"The nasal [in an initial NC- cluster]...is best analyzed as non-syllabic, with an unlinked L tone floating immediately before prefixless NC-initial nouns" (H 1986:123)

and "only linked L's spread" (H 1986:125). For the prefix tone of NC-initial nouns spreads. Such nouns can be coherently treated as having a L tone on their nasal prefix (as in A&H 1976); this tone is then eliminated by the tonetic interpretation. Finally, the tone on level 1 on V- noun prefixes can be lowered to 2.

(45) Examples of derivations in Ngamambo

m̀bàp'			˘	λtsám'			'rat of home'
0	0	1	0	0	1	1	
4	4		4	4			M1
		3					M2b
					2	2	M2c ii
					4		C1
		+s					S2
			Ø				D
4	4	3		4	4	2	
	⌒						
	3						A1
4	3			4	4	2	
(S1 cannot apply.)							

fəŋgwáŋ̀			˘	λbòè			'salt of slave'
0	1	0	1	0	0	0	
4		4		4			M1
	3		3				M2b
			(Ø)	3			C2+merger
		Ø				Ø	D
4	3			3	0		

mófóm̀			˘	λbáỳ			'fat of airplane'
1	1	0	0	0	1	0	
		4	4	4			M1
					3		M2b
		+s					S2
			Ø			Ø	D
1	1	4		4	3		

λtój'			˘	λtsám'			'ear of home'
0	1	1	1	0	1	1	
4				4			M1
	2	2	2		2	2	M2c ii
		-s				-s	S1
	4						C1+assimilation
			(Ø)	2			C2+merger
		Ø				Ø	D
4	4			2	2		

λbám`			´	λtsám´			'bag of home'
4	4	4		4			M1
			3				M2b
					2	2	M2c ii
						–s	S1
			(Ø)	3			C2+merger
		Ø				Ø	D
4	4			3	2		
(A2 is not applied.)							

´γù´			´	λbáŋ`			'thing of airplane'
	4						M1
	3						M2a
					3		M2b
		2	2				M2c i
			(Ø)	2			C2+merger
		Ø				Ø	D
1	3			2	3		
	2						A2
2							by interpretation
2	2			2	3		

#### 4. MANKON

4.1 In Mankon, there is a single distinctive tone feature,  $[\pm h]$ . All TBUs in the associative construction can coherently be treated as syllabic, although the vowel bearing the second noun-root tone is underspecified in many cases. The feature  $[\pm s]$  is therefore inappropriate. There is, however, a distinction between "solid" and "fluid" TBUs (see Stewart 1981), defined on the basis of a tone-spreading phenomenon. Noun prefix TBUs and initial root vowels are solid ( $[-f]$ ); all others are fluid ( $[+f]$ ). But this, of course, gives us the same (inverted) lexical distribution of positive and negative values as the  $[\pm s]$  feature in Dschang. In addition, there is a demarcative feature, say  $[\pm q]$ , which distinguishes noun prefix TBUs from all others; these are the only units allowed to bear a realized glide. Finally, for a language with both upstep and downstep, we will require a three-valued marking feature. In the lexicon, all tones will have the neutral value,  $[0]$ , for this feature. We thus have the following lexical matrices for the four basic noun tone patterns:

(46)

L	.L	L		L	.L	H		L	.H	H		L	.H	L
$[-h]$	$[-h]$	$[-h]$		$[-h]$	$[-h]$	$[+h]$		$[-h]$	$[+h]$	$[+h]$		$[-h]$	$[+h]$	$[-h]$
$[-f]$	$[-f]$	$[+f]$		$[-f]$	$[-f]$	$[+f]$		$[-f]$	$[-f]$	$[+f]$		$[-f]$	$[-f]$	$[+f]$
$[+q]$	$[-q]$	$[-q]$		$[+q]$	$[-q]$	$[-q]$		$[+q]$	$[-q]$	$[-q]$		$[+q]$	$[-q]$	$[-q]$
$[0]$	$[0]$	$[0]$		$[0]$	$[0]$	$[0]$		$[0]$	$[0]$	$[0]$		$[0]$	$[0]$	$[0]$

4.2 In the associative construction, the L tone of .HL nouns is shifted onto the first root vowel to form, a glide when the associative marker is H:

(47)

S <sub>i</sub>	S <sub>i</sub>	A		S <sub>i</sub>	Ø	A
H	L	H	→	HL		H
$[+h]$	$[-h]$	$[+h]$		$[+h]$	$[-h]$	$[+h]$

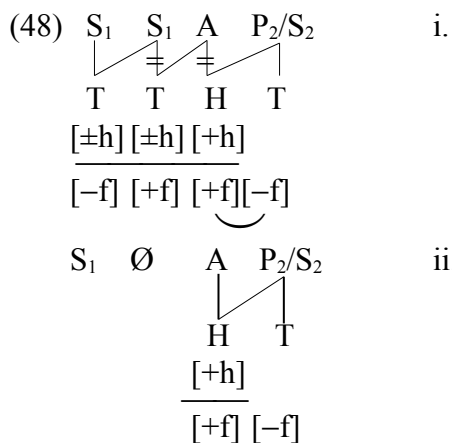
⏟

Let us assume that, when a feature is shifted to a TBU which already has a tone matrix associated with it, a second full matrix is formed by copying from the latter. Furthermore, if no feature is shifted to occupy the slot vacated by the original shift, the incomplete matrix is deleted.

At the same time, if the N<sub>2</sub> prefix has the form V-, it absorbs the vowel of the associative marker, leaving its tone in the derivation. If the associative marker is also of the form V, a succession of two tones with no intervening non-TBU, composed of the final N<sub>1</sub> root tone and the AM itself, will already have formed in most cases. These tones merge if they are the same; the L component is deleted if they are different.

4.3 *If the associative marker bears a H tone, spreading takes place between the last [-f] tone of N<sub>1</sub>, and the first [+f] tone of N<sub>2</sub>, provided the final [+f] tone of N<sub>1</sub> is still available (i.e., has neither formed a glide nor been deleted). If the final N<sub>1</sub> tone is not available, spreading begins from the AM. In the course of spreading:*

1. a [-f] tone displaces a following [+f] tone,
2. a [+f] tone displaces a following [+f] tone, and
3. a [+f] tone spreads to a following [-f] tone to form a glide. In diagram:

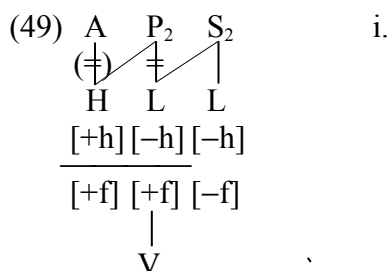


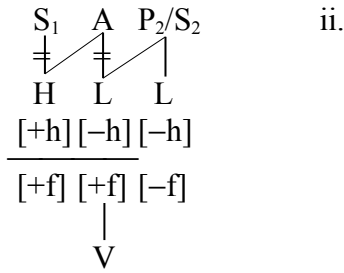
where the solid line indicates that only the distinctive feature spreads.

*If the associative marker bears a L tone, there is no spreading.*

Leroy (1977) provides the associative marker (and final noun root tones associated with a vowel matrix) with a floating copy. Whether the need for this copy is obviated by the use of autosegmental spreading rules need not concern us here. For our purposes, we can simply assume a prior merger.

4.4 There are two exceptions to the spreading rule. These allow spreading to *continue* (if the AM is H), or to *occur* (if the AM is L). The first exception is aimed at preventing a HL glide from occurring on a morpheme with the segmental form V, immediately before an initial L N<sub>2</sub> root tone, unless N<sub>2</sub> still has a L-tone prefix after the spreading process. This is obtained by:

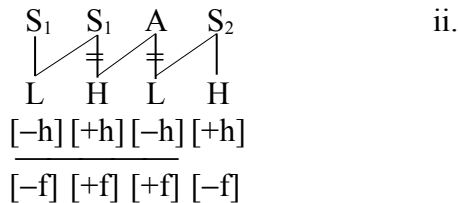
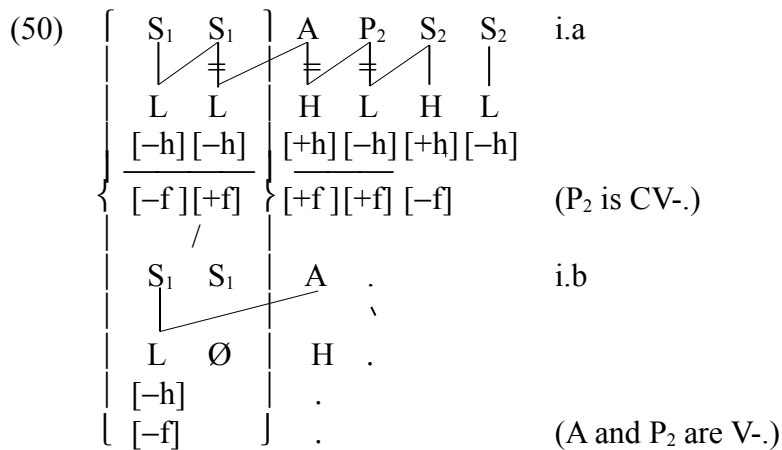




In (49i), the noun prefix tone has been marked [+f] to describe its behavior in this context. No such devices are needed in (49ii); spreading would simply *not have occurred* without this constellation.

Notice that spreading rules can easily make reference to segmental as well as tonal features. This would seem to be much more unusual, if not impossible, in assimilation rules.

4.5 The second exception is motivated by the requirement that the L↑H sequence be restricted to solid TBUs (i.e., noun prefix + first root vowel). This is obtained by:



In (50i), P<sub>2</sub> again behaves as if it were [+f]. The longer structural description in this part of the rule is due to the fact that .HL nouns as N<sub>1</sub> do not provoke continued spreading, and that .HH nouns do not receive spreading as N<sub>2</sub> (as they do in 50ii). In (50i), as in (48), spreading begins from the AM when the final N<sub>1</sub> tone is no longer in the derivation; the L initial N<sub>1</sub> tone is nevertheless still an essential part of the structural description.

If, after spreading, there is still a tone without an associated vowel matrix preceding a morpheme of the form V (AM or N<sub>2</sub> prefix), the unassociated tone is shifted onto this vowel. Naturally, two identical tones reduce to one; a L tone preceding H(L) is deleted but a H preceding L forms a HL glide.



4.6 By changing the value of the numerical marking feature, we can obtain matrices which can be interpreted as requiring downstep or upstep. Downstep results from:

$$(51) \quad 0 \rightarrow -1 / \begin{array}{ccc} [+h] & [-h] & [+h] \\ & <[-q]> & \end{array}$$

Angled brackets are again used for inclusive disjunction of the features in question, at least one of which must be present for the rule to apply. If there is a HL glide on a prefix, downstep will thus only appear if the root pattern is HL.

Notice that the value of the marking feature is not changed within the glide, but directly on the following H. This economizes a rule of transmission, of course, but primarily expresses the fact that there is no reason to assume a pitch drop in this language. Rather, there is a pitch *rise* affecting the H component of glides, which will be realized as upstep.

Upstep can be inserted directly in LH glides by

$$(52) \quad 0 \rightarrow +1 / \begin{array}{ccc} [+h] & [-h] & [+h] \\ & & \boxed{\phantom{0}} \end{array}$$

But upstep is also required as a consequence of (51):

$$(53) \quad 0 \rightarrow +1 / \begin{array}{ccc} [+h] & [-h] \\ [0] & \boxed{\phantom{0}} & [-1] \end{array}$$

(51) and (52) are obviously disjunctive and apply across a phrase from left to right. (53) applies subsequently.

4.7 The glides which have produced downstep and/or upstep are now reduced, together with any glides remaining on  $[-q]$  TBUs:

$$(54) \quad \begin{array}{ccc} [-h] & \rightarrow \emptyset / & [+h] \\ \cdot & & \cdot \\ \cdot & & \cdot \\ \cdot & & \cdot \end{array} \quad \text{i.}$$

$$\begin{array}{ccc} & & \cdot \\ & & \cdot \\ & & \cdot \end{array} \quad \text{ii.}$$

$$\begin{array}{ccc} / & [+h] & \\ & \cdot & \\ & <[-q]> & <[-1]> \\ & \cdot & \end{array}$$

The tonetic interpretation will now produce correct results, assuming that  $\begin{array}{c} [+h] [+h] \\ [0] \end{array}$  is taken as a sequence of two H tones with no change of level, and  $\begin{array}{c} [+h] [-h] \\ [-1] \end{array}$  and  $\begin{array}{c} [+h] [-h] \\ [0] \end{array}$  are considered to be HL sequences

separated by identical intervals.

(55) Examples of derivations in Mankon

bì.swàɛ̀			bí	Ø.bìɛ́			'blades of termite'
L	L	L	H		L	H	
		L	L	H	L		48i
						-1	51
				+1			53
					Ø		54ii
bìswàɛ̀			bì	'bíɛ́ʒó			

à.bùɛ̀			á	bì.lóm̀			'slave of husbands'
L	L	L	H	L	H	L	
		Ø	L	H	LH		50i+reduction
					+1		52
					Ø		54i
àbùɛ̀			à	bí'lómà			


bì.swàɛ̀			bí	Ø.kàŋ̀			'blades of squirrel'
L	L	L	H		L	L	
		L	L	H	L		48i
					Ø		54ii
bìswàɛ̀			bì	káŋ̀			


à.tí́			á	bì.lóm̀			'tree of husbands'
L	L	H	H	L	H	L	
		Ø	H	H	L		48ii+reduction
						-1	51
					+1		53
					Ø		54ii
àtí́			á	'bíslómà			

bì.lóm̀			bí	Ø.kàŋ̀			'husbands of squirrel'
L	H	L	H		L	L	
	HL	Ø					47
				HL			48ii
				-1			51
	+1						53
		Ø			Ø		54ii
bí'lóm			ʒbí	káŋ̀			

à.bùɛ̀			á	bì.síŋ́			'slave of birds'
L	L	L	H	L	H	H	
	Ø	L		HL			48i+reduction
(50i and 54 cannot apply.)							
àbùɛ̀			à	bìsíŋ́			

à.bí`			á	bì.lóm`			'ditch of husbands'
L	H	L	H	L	H	L	
	HL	Ø					47
	⌒						
				HL			48ii
				⌒			
			-1		-1		51
	+1						53
Ø				Ø			54
à'bí			śś	bíślómè			

à.t̪́´			á	à.tálém´				'tree of bat'
L	L	H	H	L	H	H	H	
		Ø	H					merger+reduction
			Ø	HL 				48ii+reduction
àt̪́				Êtálémós				

Ø.búé´			ì	Ø.ból		'chimpanzee of ball'
	H	H	L		H	H
						merger
					-1	51
		+1				53
			Ø			54ii
búé			´ú	šbórè		

Ø.bìe'			ì		bì.síŋ'			'termite of birds'	
	L	H	L	L	H	H			
		Ø	H	L			49ii+reduction		
bìe			í		bìsíŋǝ				

## 5. CONCLUSION

5.1 Tonetic variation in the languages examined above is described by one of two processes. The one used in the three Mbam-Nkam languages, Dschang, Ghomala', and Mankon, involves two steps:

1) a particular relationship is established between two neighboring tonemes to distinguish them from otherwise identical sequences of tones. In each language, this relationship has been called "gliding", though the phenomenon does not have a universal mode of existence. In Mankon, there is a distribution of glides vs. upstep/downstep which clearly suggests that the latter derive from the former. In Ghomala', the existence of realized syllabic glides provides an analogical justification for allowing unrealized asyllabic glides in the derivation. In Dschang, "gliding" refers to an abstract relationship which is merely inferred from the observed tone strings.

2) A feature change is introduced to signal a widening of the pitch interval between the glided tones.

In the Western Grassfields language, Ngamambo, however, tonetic variation is described as a result of the attraction of opposites: in certain feature contexts, the pitch interval between neighboring H and L tones is diminished.

5.2 All four languages bring about a reduction of the number of level changes in their lexical tone strings by the use of deletion rules, but Dschang and Ngamambo are alike in using assimilative leveling rules as well.

Evidence of spreading (as defined in 0.1) appears in all four languages; however, only in Mankon are spreading rules sure to be required for the associative construction.

5.3 It may be helpful to envisage the spreading/assimilation contrast as part of a larger set of tone-shifting processes. Either one may be the *end process of shifting by displacement* over any number of TBUs. Shifting by displacement can, in fact, end in one of three ways: 1) exhaustion (a type of spreading where, for example, H L H L L → H H L H L after rightward shifting from one TBU to the next), 2) containment by conjunction (a type of spreading where, for example, H L H L → H H L HL), or 3) containment by assimilation (when L H L H → L L H 'H).

All rules involving shifting by displacement should be statable in a similar way. In fact, the rules which assimilate a feature of a single neighboring tone in the descriptions above can be treated as minimal cases of feature shifting contained by assimilation.

Autosegmental diagrams attempt to capture shifting in all its forms as a simultaneous phenomenon. Requiring a formal theory to be representable by two-dimensional diagrams is, however, too restrictive in most cases, and probably here as well. The danger is that more attention may be devoted in descriptive work to problems of depicting rules than to the analysis of languages.

The development of a formal vocabulary allowing the different components of the shifting process (direction, boundaries, end process, etc.) to be succinctly stated in rule form with reference to feature matrices is certainly both possible and desirable. Rules using this vocabulary should allow patterns to move directly from a prior state (say H L H with marked final H) to a subsequent one (say H H H, interpreted as involving downstep) without intermediate stages for which there is definitely no synchronic, and perhaps no diachronic proof (e.g., H L H → H HL H).

According to this view, the rule forms used above for convenience to distinguish spreading and assimilation would be converted into clearly individuated forms within a single new framework.

5.4 The preceding discussions should suffice to show that there is a part of tonological analysis which can, without forcing, be made to bear a close resemblance to a relatively traditional type of phonological analysis. Through feature analysis, a compact set of tonological rules can be developed and stated in a readable form which seems intuitively acceptable as a representation of the linguistic processes involved.

The descriptions above are nevertheless a mere formal exercise. As there is no way of measuring whether they correspond better to what the speakers of the languages concerned are actually doing, all analyses which account for all the facts are equally valid. These descriptions should therefore be compared with the original presentations in the cited works (see also Stewart's 1981 analysis of Dschang, involving the notions of "solid" and "fluid" syllables). Each approach should be able to provide some insight into the nature of the languages described, and should be judged on the basis of how far it does so.

5.5 Nothing has yet been said about the possible formal classification of marking features. Are they entirely "language-specific", and invented to suit whatever a given system requires? The answer to this question is not clear from just these examples. A larger variety of such analyses might allow us to abstract a typology and statistically quantify the types of system observed, but this cannot be guaranteed. This paper does no more than lead us to expect that, when presented with a full and coherent set of data and an insightful interpretation (as through the notion of "floating" tones) of a language with different classes of tonetic realizations of its tonemes, we will be able to set up a suitable system of features and feature-changing rules to describe it.

Les années 1980 voyaient le développement d'une approche de la phonologie et de la tonologie qui fonctionnait moyennant la minimalisation de la spécification des valeurs des traits, autrement dit, par "sous-spécification" (vd. par exemple Pulleyblank 1986). Cette appendice présente brièvement une variante de l'analyse appliquée ci-dessus aux langues des Grassfields, mettant en oeuvre une sous-spécification initiale.

### *Appendix*

#### An alternative analysis by underspecification

A.1 If one begins derivations with a full feature specification for all tones, the rules leading to downdrift and downstep will not only be somewhat complicated, but will furthermore be exposed to the valid objection (cf. Clements and Ford 1979:189) that for no good reason they must be applied cyclically from tone to tone across a string.

Let us then allow the features [q] and [r] initially to have a third (neutral) value with positive and negative values being activated, so to speak, in the course of derivation.

Downdrift can be obtained by a first simple activation rule:

$$(1) V \rightarrow +V / [\alpha h][-\alpha h] \\ \quad \quad \quad [ \_ ]$$

$V$  is a variable, either  $q$  or  $r$ . One of these features is associated with  $[\alpha h]$  as the rule applies recursively across a string, whereupon the other is associated with  $-\alpha h$ .

By (1), for example, a HLLH sequence can be specified as:

$$(2) \begin{array}{cccc} H & L & L & H \\ [+h] & [-h] & [-h] & [+h] \\ [q] & [+q] & [q] & [q] \\ [r] & [r] & [r] & [+r] \end{array}$$

where the feature [q] is made to take a positive value with the shift from  $[+h]$  to  $[-h]$ , whereafter [r] takes a positive value with the shift from  $[-h]$  back to  $[+h]$ .

A.2 Downstep may be achieved after an assimilation rule. It is imperative, however, that formal conditions allow the switching of a single feature in a sequence of tones, in this case the distinctive feature:

$$(3) [-h] \rightarrow [+h] / [+h][\_ ] (...) [+h]$$

where the suspension points represent an uninterrupted sequence of tones with a feature identical to that of the immediately preceding tone.

A.3 Rules (1) and (3) describe downstep with rightward spreading. Leftward spreading is more complicated to describe, and requires that (1) be replaced by a rule which provides separately for activation of the values of features [q] and [r].

$$\begin{array}{ll} (1') \text{ a. } q \rightarrow +q / \text{ i. } [+h][-h] (...) \# & \\ & \quad \quad \quad [\_ ] \\ & \quad \quad \text{ii. } [+h][-h] (...) [+h] (...) \\ & \quad \quad \quad \quad \quad [\_ ] \\ \text{b. } r \rightarrow +r / \text{ iii. } \# [-h] (...) [+h] (...) & \\ & \quad \quad \quad \quad \quad [\_ ] \\ & \quad \quad \text{iv. } [+h][-h] (...) [+h] & \\ & \quad \quad \quad \quad \quad [\_ ] \end{array}$$

By (1'), the sequence HLLH takes the features:

$$\begin{array}{cccc} (4) & H & L & L & H \\ & [+h] & [-h] & [-h] & [+h] \\ & [q] & [q] & [q] & [+q] \\ & [r] & [+r] & [r] & [r] \end{array}$$

to which rule (3) may be applied to obtain assimilation.

A.4 These simple rules provide for generalized downstep, i.e., they describe a language which has no L tones elsewhere than in utterance-initial and utterance-final positions. To obtain the description of a real language, one will generally have to provide grammatical restrictions to the application of rule (4) at least (perhaps to (1) and certainly to (1') as well), i.e., allow it to apply only to the tone patterns of some definable set of words or phrases.

Rules (1) and (1') are shorthand for a set of rules which first activate the value of a feature of a tone preceding a change of level, and then provide for the transfer of this value to the same feature of the following tone (with subsequent reversion in the case of (1'iv)). Whether such a set of rules would have to be developed in full cannot be said in the context of an abstract discussion such as this.

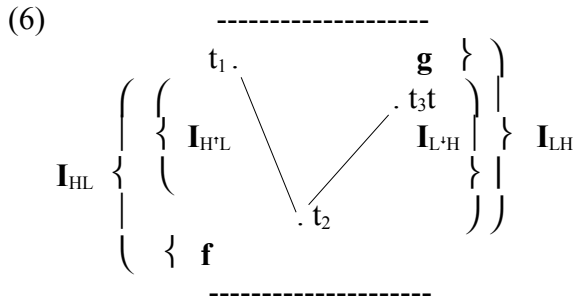
A.5 The final step in any derivation consists of activating all unactivated nondistinctive feature values according to the value of the feature [h]. Rule of tonetic interpretation will then be applied to fully specified matrices.

A.6 We may now discuss what kind of tonetic interpretation may be envisaged within this framework. Let us begin with the matrix for the sequence  $t_1 = H$ ,  $t_2 = L$ ,  $t_3 = H$ , fully activated following the application of only rule (1), i.e., in a system with downdrift and no downstepping:

$$\begin{array}{ccccc}
 (5) & H & L & H & \\
 & [+h] & [-h] & [+h] & \\
 & [+q] & [+q] & [+q] & \\
 & [-r] & [+r] & [+r] &
 \end{array}$$

A constant interval  $\mathbf{I}_{HL/LH}$  must first be defined for any sequence of two different tones, whose features are as in (1), whence  $\mathbf{I}_{HL} = \mathbf{I}_{LH}$ . When a L tone has the features of  $t_2$  in (5), we will write  ${}^tL$ , and when a H tone has the features of  $t_3$ , we will write  ${}^tH$ . By definition,  $\mathbf{I}_{HL} > \mathbf{I}_{H^tL}$ , and  $\mathbf{I}_{LH} > \mathbf{I}_{L^tH}$ . The value of  $\mathbf{I}_{HL/LH}$  is thus, in fact, arbitrary, but can be chosen to facilitate calculation. It is, of course, furthermore established by definition that  $\mathbf{I}_{HH} = \mathbf{I}_{LL} = 0$ .

A.7 As shown in diagram (6), values  $\mathbf{f}$  and  $\mathbf{g}$  can now be assigned to  $\mathbf{I}_{HL} - \mathbf{I}_{H^tL}$  and  $\mathbf{I}_{LH} - \mathbf{I}_{L^tH}$ , respectively. Tonetic realization can then be calculated by assigning any possible initial pitch  $p$  to  $t_1$ .  $t_2$  is then  $a - \mathbf{I} + \mathbf{f}$ , and  $t_3$  is  $a - \mathbf{I} + \mathbf{f} + \mathbf{I} - \mathbf{g} = a + \mathbf{f} - \mathbf{g}$ .



It is thus easily seen that, in this simple system, the pitch of any tone,  $P(t_N)$ , is:

$$(7) \quad P(t_N) = \int (p, \mathbf{I}, i\mathbf{f}, j\mathbf{g})$$

where  $i$  and  $j$  are positive integers. In more complicated systems, particularly where  $\mathbf{f}$  and  $\mathbf{g}$  are not constant, a more complex defining function will naturally be required.

A.8 Let us now consider the sequence HH'H, obtained by application of rule (3) to the HLH sequence whose matrix appears in (5). The fully activated resulting matrix is:

$$\begin{array}{ccccc}
 (8) & H & H & {}^tH & \\
 & [+h] & [+h] & [+h] & \\
 & [+q] & [+q] & [+q] & \\
 & [-r] & [-r] & [+r] &
 \end{array}$$

The tonetic interpretation should be obtainable by defining  $\mathbf{I}_{H^tH} = \mathbf{g} - \mathbf{f}$ . More complex interpretations can be developed for systems with more contrasting levels and/or more possible downstep combinations.

A.9 This framework constitutes a reasonably intuitive representation of the simplest type of downstepping process: a tone is marked each time there is a change of level, yielding downdrift. Downstepping then consists of reducing a sequence of three different feature matrices to two identical matrices and a different third one. Reduction is assured for the tonologically distinctive feature by a leveling assimilation.

A.10 Languages with downstepping that is not derivable from feature spreading can also be dealt with by this approach. In Zande (Boyd 1981), for example, downstepping is used as a syntactic marker under conditions which leave no grounds whatsoever for supposing that a L tone has been assimilated. Rather than applying rule (1)/(1') and (3), Zand would, in certain contexts, apply a rule somewhat like the following simplified one:

$$(9) r \rightarrow +r / \left[ \begin{array}{c} \left[ \begin{array}{c} \left[ \dots \right] [+h] \end{array} \right] \left[ \begin{array}{c} \left[ +h \right] (\dots) \end{array} \right] \\ \left[ \begin{array}{c} \text{NP} \end{array} \right] \left[ \begin{array}{c} \text{L}_N \end{array} \right] \quad \left[ \begin{array}{c} \text{N} \end{array} \right] \left[ \begin{array}{c} \text{L}_N \end{array} \right] \quad \left[ \begin{array}{c} \text{N} \end{array} \right] \left[ \begin{array}{c} \text{NP} \end{array} \right] \end{array} \right]$$

The first tone of a final H-tone noun in a noun phrase is thus marked after a final H tone on the preceding morpheme. The final, fully specified matrix can be interpreted for downstep in the same way as (8).

A.11 The preceding discussion thus assumes that downsteps are described by the creation of sets of marking features. Likewise, features (rather than tones as monolithic entities) are subject to transfer. The use made of glide formation and reduction by Hérault (1978) in describing Adiukru (one of the descriptions on which Stewart bases his 1983 paper) is thereby excluded.

If tone classes may be defined which are based on patterns distinguishing only the number of level changes, there nevertheless seems to be no decisive case where tone rules should be required to act directly on this patterns rather than on their projections onto tone-bearing segments. The data are equally well served by rules which change the value of a single feature of a sequence of tones having the same value for that feature.

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